Coastal Engineering Technical Note

GROINS - THEIR APPLICATIONS AND LIMITATIONS

PURPOSE: To describe the functional applications, limitations, and general design concepts of groins. This note is intended to provide a brief, general discussion of groins for Corps personnel who do not have a background in the functional design of coastal structures, and to provide useful information for answering inquiries from the general public concerning the use and construction of groins.

FUNCTIONAL APPLICATIONS: Groins are long, narrow structures placed approximately perpendicular to the shoreline to:

1. Build or widen a beach by trapping littoral drift (wind-blown sand may also be trapped).
2. Stabilize a beach by reducing longshore transport out of the groin compartmented area.
3. Reduce the rate of longshore transport out of an area by reorienting a section of the shoreline to an alignment more nearly perpendicular to the predominant wave direction.
4. Prevent loss from an area by acting as a littoral barrier (terminal groins).

The sand accumulated by the groins acts as a wave-energy-spending beach to provide additional shore protection. The use of beach fill as a shore protection structure is discussed in CETN-III-11 (Protective Beaches).

Figure 1 shows groins in a beach environment. Note that the accumulation of material (accretion) on the updrift side is accompanied by a corresponding amount of erosion on the downdrift side of the groin. As a result, two site considerations that are vital to the applicability of groins are: (1) in order for sand to be trapped, there must be an adequate supply

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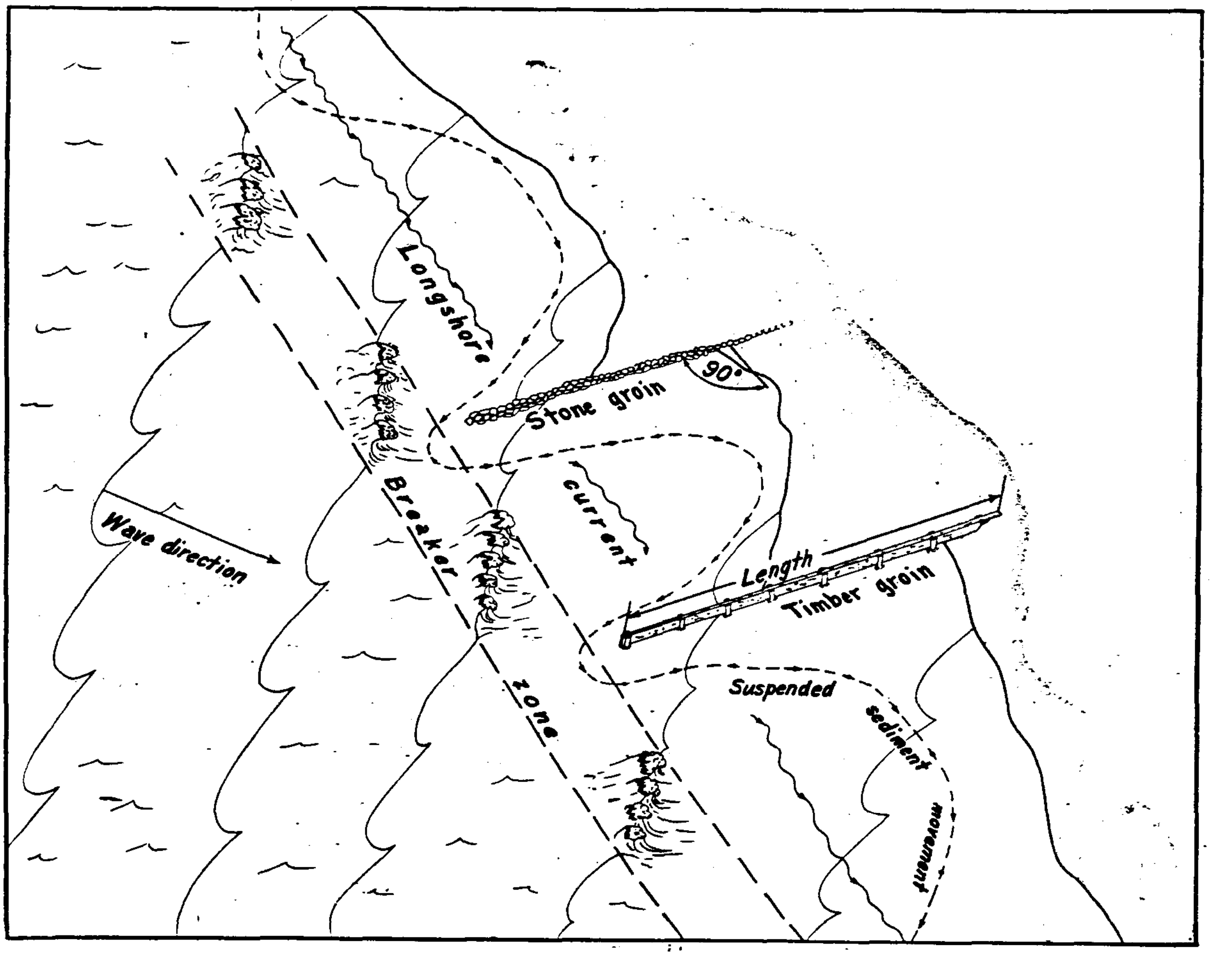

Figure 1. Groins in a Beach Environment

of sand moving along the shore, and (2) there is always a potential for erosion problems downdrift of the groin. Therefore, consideration must be given to combining groin construction with a program of artificially filling the beach. A problem with groin-system design is the difficulty of evaluating the direction of the longshore current and the amount of the sand being transported by this current.

<u>FUNCTIONAL LIMITATIONS</u>: If there is an inadequate longshore movement of sand, then a groin may not accumulate enough sand to prevent erosion adjacent to the groin. If the groin loses its trapped beach, it cannot, by itself, protect the shoreline from direct wave attack. Other structures may be necessary to fulfill that function and plans to periodically refill the compartments may be required.

If the updrift groin in a series is constructed first, then the downdrift groins may fall in the erosion zone of the updrift groin resulting in the loss of any sand that might have filled the compartments between groins. This can be remedied, if some erosion of the downdrift beach can be tolerated, by building the most downdrift groin in the series first, then allowing sand to accumulate against it before the next groin updrift is built. The groin construction would then continue in an updrift direction until the system covers all the problem shoreline. If it appears this procedure produces unacceptable erosion of beaches downdrift of the groin field, then the natural accretion updrift of the groins will have to be supplemented by artificial beach fill. The recommended practice is to provide beach fill any time groins are constructed. Groins are unable to control or retard offshore movement of sand; and, consequently, they are unsuitable where this onshore/offshore movement is dominant.

Short groins may induce rip currents that jet the littoral drift past the end of the groins and deposit the sand further seaward than the normal offshore bar. This sand may then be lost to the littoral system. Although rational methods are not available for determining precise design dimensions to insure rip currents will not form, the designer should be aware of this possibility and recognize that construction of short groins may require later modification by increasing their length, and/or reducing the spacing between groins by constructing additional groins between those already built.

All groins and groin systems should be carefully monitored after construction to assure that they perform as designed.

STRUCTURAL ASPECTS: The design of groins is discussed in the *Shore Protection Manual* (SPM). Briefly, the design characteristics of groins are as follows:

1. Alignment. Alignment at 90 degrees to the shoreline is illustrated in Figure 1. Alignments at various angles to the shoreline have been tried, as well as projections placed at the end of groins to form "T" or "L" shapes; however, experience indicates that in most cases straight structures perpendicular to the shore are just as effective, and they are easier to construct.

2. Permeability. Permeable groin structures permit some sand to pass through the groin, but experience has shown that such structures are generally ineffective and are difficult to design, operate, and maintain. A low impermeable groin is preferable when controlled bypassing is desired.

3. Height. The height of a groin depends on the degree to which it is desirable for sand to overtop the groin and replenish the downdrift beach. The minimum height is about the same height as the beach berm height. The outer sections of the groin generally decrease in height seaward. Normally, the outer section elevation is several feet above the beach profile. Lower groins, which follow the profile of the existing beach, help stabilize the native beach sand but impound very little of the longshore transport. Higher groins, projecting more than several feet above the existing beach profile, tend to be complete littoral barriers. Long, high groins that eliminate bypassing are called terminal groins, and are commonly used at the downdrift end of beach fills to keep artificially-placed sand from moving out of the protected area. Terminal groins can be used only where erosion of downdrift shorelines will be slight or can be tolerated, or where they will prevent harmful shoaling of navigation channels by bypassing sand. Groins of adjustable height, built of panels which could be placed or removed to vary the volume of bypassed sand, have been tried but tilting or distortion of the panels and frame guides have made panel adjustments difficult; generally, adjustability has been found to be impractical.

4. Length. A groin's length must be sufficient to create the desired beach profile while allowing the adequate passage of sand around the groin's outer end. As discussed in CETN-III-11 (Protective Beaches), a design beach berm width is chosen which provides the required protection or recreational area; and the slope of the beach seaward of the berm is then assumed to parallel the existing beach. If groins are used to protect a beach fill, the outer end of the groin would be placed where the designed beach slope intersects the existing bottom. Since most of the sediment transported along the coast moves within the breaker zone, groins that extend seaward of that zone may force sand to flow too far offshore to be returned to the downdrift beach. In special cases groins may be constructed shorter in order to trap a smaller amount of sand. At the landward end, a groin must be well secured to the shoreline to prevent flanking (scouring of the area landward of the

groin's end). The SPM presents a method of estimating the maximum shoreward scour along the groin. The groin should be extended into the backshore beyond the expected scour area, or anchored to a hard structure or natural formation.

5. Spacing. The correct spacing of groins is often difficult to determine and is a function of structure length and desired final shoreline shape. If groins are too far apart, excessive erosion can occur between them. If spaced too closely, they may not function properly to trap sand moving along the shore. A general rule of thumb is to space groins 2 to 3 times the groin length from the high water line to its seaward end, but site conditions can dictate use of the more complex design method detailed in the SPM, leading to considerable variation from this rule.

The length, height and permeability are the most important parameters affecting structural design. They influence the amount of accretion and erosion around the groin and the length of the groin exposed to wave forces. Dynamic forces, which affects the structural design, are caused by waves, currents, and the impact of floating debris. The critical design condition often is the static force of the soil-loading resulting from high beach level on one side of the groin and a low level on the other side. Another design force to be considered in colder climates is the horizontal and upward thrusts by ice on the groin.

Groins are either sheet-pile structures that depend on their ground penetration for support, or gravity structures which depend on their weight to resist overturning and sliding. Sheet-piles may be timber, steel, or reinforced concrete. Figure 2 shows a typical timber sheet-pile groin. CETN-III-7 (Bulkheads) presents some additional aspects of using sheet-piles in the coastal zone. Since the sheet-piles alone generally can not resist the lateral force resulting from the differential

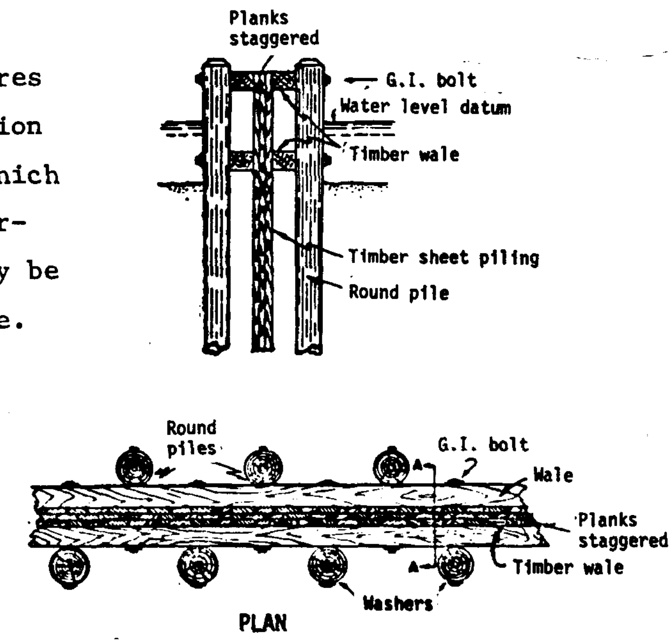

Figure 2. Timber Sheet-Pile Groin

level of sand on either side of the groin, or ice loading, timber and generally steel sheet-pile groins require the structural support of longer, round timber piles driven to a greater depth.

Where ground penetration would be inadequate to support piling, or where piling is uneconomical, gravity structures must be used. The most common type is the rubble-mound groin consisting of an impermeable core protected by armor stone and sometimes sealed with concrete or asphalt grout. Rubble-mound structures are discussed in detail in the SPM. Another type is the cellular sheet-pile groin which is a series of chambers built of steel sheet-piles driven to shallow penetration, then filled with sand or rock topped by wave-protection armor stone or paving. Cellular sheet-pile structures are discussed in CETN-III-7 (Bulkheads).

Scour of the bottom alongside a groin must be controlled. Scour is usually concentrated at the seaward end and on the downdrift side. Scour can reduce the effective soil support for pile groins until they tilt, and scour can also undermine the toe of gravity structures until the armored surface unravels and exposes the core. The effects of erosion at the landward end can be reduced by tying the groin into the dune, bank, or bulkhead. The seaward end can be protected with quarrystone scour aprons placed on geotechnical filter fabric, crushed stone, or coarse sand.

MATERIALS: Rubble-mound groins are relatively damage resistant and easily repaired; but, being the heaviest of the types, may produce foundation settlement leading to unacceptable loss of structure height. Sheet-pile cells are also heavy structures subject to settlement. Sheet-pile groins of wood require a supporting framework of wales and structural piles; whereas, groins of steel and concrete generally do not. Timber must be pressure-treated with preservatives to prevent rot in freshwater, and fouling and other infestations in saltwater. Steel piling, in the form of cells, are used where the soil is dense or contains rocks or other hard materials. To prevent the corrosion of steel in seawater, appropriate protective coating can be applied or special corrosion resistant steel can be used.

DESIGN CONSIDERATIONS:

1. A groin, or a groin system, can provide a recreational and/or protective beach only if waves and currents transport sufficient quantities of sand

along the shore to cause or maintain an accumulation alongside a groin or between groins, or if it is filled artificially.

2. Groins that fill only by entrapment of littoral drift are likely to increase the erosion rate along the shore for some distance downdrift of the structure site. Unless the area downdrift can be sacrificed, filling the groin system with imported sand at the time of construction, and in some cases refilling it later, will be necessary.

3. A groin's length and height must be chosen to maximize the accumulation on the updrift side, while minimizing the erosion downdrift. The spacing of groins in a system must be selected to maximize sand accumulation within the compartments. The economics of reducing the number of groins and their length must also be considered.

4. A groin must be stable against earth pressures created by the difference in sand levels on the two sides. It must also be stable against wave, current, and ice forces. Resistance can be developed by providing rubble-mounds and cells with adequate weight and base width, or by providing sheet-pile structures with sufficient penetration. The foundation must be adequate to support the weight of gravity structures without undergoing unacceptable settlement.

5. A groin must resist the scour created by waves breaking on the structure and currents adjacent to it. This scour can reduce the effective pile penetration, or can undermine rubble-mound structures. To design for scour, longer sheet-piles can be driven and toe-protection aprons can be added for either sheet-pile or rubble-mound groins.

6. The groin must be constructed to prevent failure due to flanking. The landward end must be extended into the shore or upland, or tied to protective structures running along the shoreline.

<u>MATERIAL SELECTION FOR GROINS</u>:

1. Quarrystone, of suitable size and structural properties for use in rubble-mound groins and scour aprons, may not be economically available in all coastal areas of the United States. Where available, quarrystone may be the preferable material for groins, and especially if they are to be located in environmentally sensitive areas. Rubble structures provide good habitat for marine organisms, while sheet-pile groins provide

less desirable habitat.

2. Sheet-pile groins require pile drivers for construction and may require pile removal equipment for repair. The construction of rubble-mound groins involves the use of a variety of heavy construction equipment. Access to the construction site must be available if such equipment is required. Installation of steel and concrete sheet-piles involves skilled labor, high material and fabrication costs, and heavier construction equipment than that required for timber sheet-piles.

3. Pretreatment, to retard deterioration, is always required for timber and may be required for steel used in saltwater. In addition, maintenance is necessary to control the rotting and splintering of wood, the corrosion of steel, and the spalling of concrete. Timber structures often can be repaired by bolting new members over broken ones or in place of damaged sections, but damaged components of steel and concrete structures must be entirely replaced. Rubble-mound structures can be repaired by adding new quarrystone to the damaged area.

REFERENCES:

Shore Protection Manual. 1984. 4th ed., 2 vols, U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, U.S. Government Printing Office, Washington, D.C.

U.S. ARMY CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, Fort Belvoir, VA., 1981:
CETN-III-7, "Bulkheads - Their Applications and Limitations,"
CETN-III-11, "Protective Beaches - Their Applications and Limitations."